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Measuring Environmental Logistics Practices

Seong-Tae KIM* · Chul-Hwan HAN**

Contents

Abstract

Current scales do not reflect the multi-dimensional nature of environmental logistics practices (ELPs), and thus cannot adequately measure the entire domain of its practices in the supply chain. In an attempt to fill this gap, the purpose of this study is to develop a valid and reliable scale for measuring ELPs. Based on the relevant literature together with the previous exploratory research, ELPs are proposed as three a priori dimensions: internal environmental management (IEM), environmental sourcing and packaging (ESP), and environmental process design (EPD). With data collected from 129 Korean logistics companies, two measurement models of ELPs were systemically analyzed by using confirmatory factor analysis (CFA). The results show that the validity and reliability of the scale for measuring ELPs are adequately established. Specifically, three basic dimensions (i.e. IEM, ESP, and EPD) are well suited for evaluating ELPs, and the proposed second-order structure is adequately supported with the systematic and scientific procedures. These indicate that ELPs can be conceptualized as a multi-dimensional measure comprising IEM, ESP, and EPD.

Key words : Environmental logistics, Practice measurement, Korea

* Graduate Student of Inha University, Korea, Email: kimnalda@naver.com, First Author
** Professor of Dongseo University, Korea, Email: chhan16@dongseo.ac.kr, Corresponding Author

I. Introduction

As public awareness of environmental issues has dramatically increased in recent years, corporate environmental strategy has emerged as an important organizational philosophy to respond to environmental impacts, which may create serious constraints on corporate sustainability.[1)] In this way, such environmental strategies have generally been assumed to create a competitive edge for a firm, and to have a positive impact on environmental performance.[2)] As a result, integrating natural environment into business strategy has become increasingly important for firms to gain and maintain sustainable competitive advantage.

OECD/ITF has shown that logistics is one of the significant sectors that contribute to overall greenhouse gas (GHG) emissions in the world (23.3% in 2005). Conversely, it would mean that this area has great potential opportunities for firms to mitigate environmental impact.[3)] Nonetheless, there has been less attention paid to the environmental issues in the logistics area. Moreover, there has been no systematic attempt to measure corporate environmental logistics practices (ELPs). To measure ELPs in a highly effective way, some useful and testable multi-item measurement scales are needed. Many of past studies on environmental logistics, however, have regarded ELPs as a sole indicator[4)] or have simply regarded it as an element of the dimensions that constitute green supply chain management (GSCM).[5)] In this regard, it would be assumed that there might be no specific guidance for especially logistics managers to address environmental issues and to proactively respond to these issues.

Therefore, appropriate measurement scales for evaluating ELPs are clearly needed to complete the robust research as well as to advance the body of knowledge. Based on the literature in logistics and environmental management, we attempt to introduce multi-item ELPs scales that

1) Miles and Munilla(1993), pp. 43-50; Hart and Dowell(2010), p.2.
2) Porter and van der Linde(1995), pp.119-134.
3) Wu and Dunn(1995), pp. 20-38; González-Benito and González-Benito(2006), p.1353.
4) e.g. González-Benito and González-Benito(2006).
5) e.g. Holt and Ghobadian(2009).

may be used to help evaluate environmental practices in this area. This measurement instrument would enhance the understanding of how logistics managers address environmental issues, and how these managers facilitate environmental practices to meet the needs of customers better than the competitors. Taken together, such an instrument is necessary not only for practitioners to investigate and manage their current environmental activities but also for researchers to define and conceptualize the domain of ELPs constructs.

Given the above discussion, this paper attempts to investigate the ELPs construct, and develop a valid and reliable scale for measuring the environmental practice adoption from the Korean logistics industry. To achieve these, we first provide a conceptual background of measurement items of ELPs. Specifically, we review environmental logistics activities in the literature, describing its activities that have performed in South Korea. In section 3, we first propose hierarchical factor structure of ELPs, and the process of measure development and data collection are then described. And then, statistical analysis will be systemically illustrated in section 4. In the final section, we conclude with theoretical and practical implications, and several research limitations are also described.

II. Literature review

1. Environmental logistics practices (ELPs)

Traditional logistics systems emphasize too narrowly the need to minimize costs and maximize profits in their operation, while environmentally responsible logistics adds another objective into that traditional system: minimizing negative environmental impact.[6] In this study, environmental logistics practices (ELPs) refer to environmental activities undertaken by logistics firms across the supply chain, ranging from internal environmental management to packaging, warehousing, freight transportation, and to reverse logistics. These practices mainly focus on minimizing negative environmental

6) Wu and Dunn(1995), p.24.

impacts, maximizing logistics efficiency in the supply chain context.

As we mentioned earlier, corporate environmental strategy has recently come to the fore as an effective business philosophy, and it has been known that environmentally friendly logistics systems may provide a great potential for contributing to corporate environmental performance. In this way, many previous researchers have proposed and developed a variety of models and frameworks for evaluating environmental logistics strategies. More detailed explanations about measurement issues in the environmental logistics literature are as follows.

Some authors have conceptually described a domain of logistics activities in the green supply chain context. Wu and Dunn specified the practical domain of environmentally responsible logistics activities in the supply chain; they proposed six types of logistics elements to identify certain activities that may interface with the natural environment.[7)] In their model, these elements include purchasing, inbound logistics, transformation, outbound logistics, marketing, and after-sales service. Sarkis also developed a strategic decision framework for the green supply chain evaluation, and they defined the domain of logistics activities in the supply chain: procurement, production, distribution, reverse logistics and packaging.[8)]

On the other hand, there are a few mathematical modelling approaches regarding environmental measures explicitly during the optimization process at the same time as traditional objectives. Quariguasi Frota Neto et al.,[9)] in their study, used multi-objective optimization techniques for designing and evaluating sustainable logistics networks. The authors expected that this approach may provide an appropriate framework to measure environmental impact in each phase of the supply chain. In another case, Sundarakani et al. used the long-range Lagrangian analytical model to examine the carbon footprint across the supply chain, which may contribute to the body of knowledge in green supply chain management (GSCM).[10)]

As regards the role of logistics in corporate environmental strategy, there

7) Wu and Dunn(1995).
8) Sarkis(2003).
9) Neto et al.(2008).
10) Sundarakani et al.(2010).

were many studies showing how important logistics activities are in a way that mitigates the environmental impact. Aronsson and Huge-Brodin focused on certain logistics practices such as consolidation, modal selection, and distribution network design.[11] Then, they conducted three case studies to see how firms contribute to environmental improvement especially through the structural changes of logistics network. Similarly, Kohn and Huge-Brodin also described two case studies to show how environmental improvements can be achieved by changing transport flows from decentralised to centralised distribution systems.[12] They pointed out that centralised distribution system often results in an increase of total distance for the transport work; but it also has a positive impact on the reducing transport work by improving shipment consolidation and reducing emergency deliveries.

Despite these previously proposed frameworks and models that have incorporated various domains and characteristics of ELPs, these studies were not without limitations. Specifically, previously conducted studies do not reflect the multi-dimensional nature of environmental logistics practices (ELPs), and in turn it cannot adequately measure the entire domain of its practices. On top of that, none have empirically attempted to develop and validate a scale for evaluating these practices. This scant research area leads us to investigate reliable measurement scale for evaluating ELPs. We expect that the present study may complete robust environmental logistics research and further provide proper guidance for logistics managers to adroitly respond to the environmental challenges.

2. Environmental logistics in South Korea

Public concern about the natural environment in South Korea just began to emerge in the early 1990s.[13] Until then, government policies placed top priority on economic growth. However, the Kyoto Protocol calling for developed nations to cut GHG emissions[14] has driven Korean to turn its attention to the natural environment. In this way, central government

11) Aronsson and Huge-Brodin(2006).
12) Kohn and Huge-Brodin(2008).
13) Lee(2008), p.187.
14) The Kyoto Protocol called for developed nations to cut GHG emissions by 6% compared with the standard year of 1990 levels.

proposed a national development strategy, which is called "Low Carbon Green Growth", in August 2008. This strategy refers to a mean of responding to the environmental crisis for the sustainable development. In addition, the Presidential Committee on Green Growth (PCGG) was created in February 2009, and the Green Growth Law is being deliberated in the National Assembly. The specific mission of PCGG is to spread the vision of green growth to all sectors of society in a practical fashion.

According to OECD/ITF (2010), the transport sector accounts for 24 percent of total CO_2 emissions in Korea, which is the second largest emitter after the energy (47%) in 2007. Focusing on freight transport, it has nearly 30 percent of the total transport CO_2 emissions.[15] On top of that, almost all goods transport depends largely on the road sector (76.6% of the total cargo transportation quantity)[16], which is regarded as the environmentally inefficient transport mode. Moreover, the dependence on its road sector has gradually grown over time while the portion of other cleaner modes such as railroad and coastal shipping are relatively decreased.[17] Given the situations, the environmental problems caused by activities in the logistics area would not be underestimated.

As a result, there is a government effort to reduce GHG emissions from freight transport with various supporting systems. August 19, 2008, the Ministry of Land, Transport and Maritime Affairs introduced 'green logistics partnership' and 'green logistics certification system' to provide benefits to logistics firms. The green logistics partnership refers to a joint effort between cargo owners and logistics players to reduce CO_2 emissions. On the other hand, the green logistics certification system represents a government policy that provides incentives to environmentally authorized logistics firms to reduce energy consumption. Government expects that the reduction of GHG emissions can be achieved under these systems.

Policy maker expects that both supporting systems and legislation would bring benefit to alleviate freight's dependency from the road sector. That is to say, it can increase the capacity of the freight rail and coastal shipping, which

15) Hwang and Park(2010), p.14.
16) Kim et al.(2011), p.307.
17) Kim et al.(2011), p.307.

are being regarded as a more energy efficient and the environmentally friendly transport mode. This is called 'modal shift' that changes transport mode from dirtier (e.g. road) to cleaner (e.g. railroad). Furthermore, these policies have been regarded as one of the top priority project for reducing logistics related GHG emissions and the policy is now being pushed forward under the name of green logistics initiative.

These governmental efforts towards sustainability have also led Korean logistics firms to consider environmental issues. According to the report conducted by the Korea Chamber of Commerce and Industry (KCCI) in 2010, awareness of the Korean logistics industry for the natural environment has gradually grown over time; about 36 percent of total respondents (300 logistics-related firms) have specified teams or employees for managing these environmental issues. Dongbu Express, for example, which is a leading integrated logistics firm in Korea, formed a task force team for responding to environmental issues, and they have met together at least once a month to discuss successful ELPs. In addition, the report has shown that most logistics firms have considered the adoption of ELPs, especially in freight transport efficiency and reverse logistics practices.

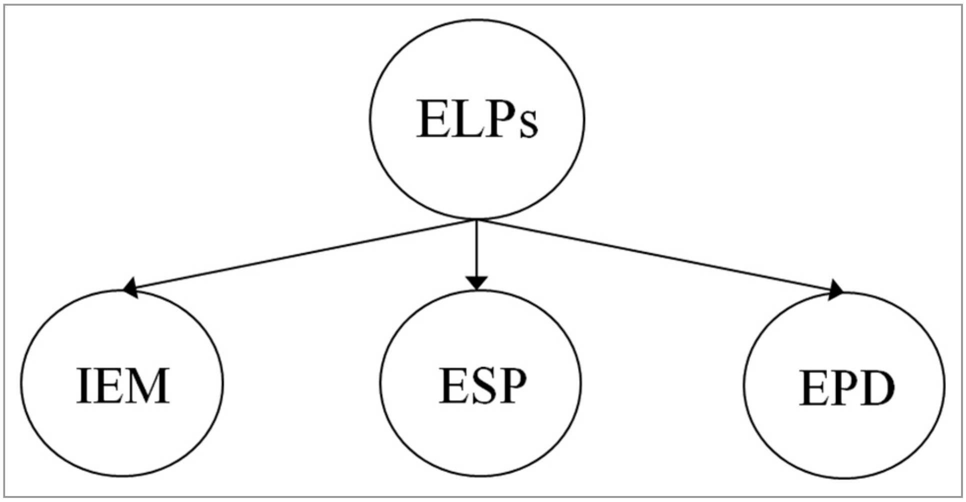
III. Methodology

1. Proposed factor structure for ELPs

Combining findings from the review of environmental logistics literature and based on the previous exploratory study, we propose a hierarchical factor structure of ELPs that is comprised of three underlying sub-dimensions: internal environmental management (IEM), environmental sourcing and packaging (ESP) and environmental process design (EPD) (see Figure 1). The rationale for the hierarchical factor structure is as follows. Even though the literature have described various logistics activities that interface with the natural environment in the supply chain, an empirical examination to develop and validate a scale for evaluating environmental logistics practices (ELPs) has yet to be fully investigated. Furthermore, although logistics activities are diverse in each phase of the supply chain, previous studies have regarded ELPs as an element of GSCM dimensions[18] or as a sole indicator.[19]

The first proposed dimension is IEM. It has been argued that environmental emissions can be prevented by the combination of internal management efforts such as environmental audit system.[20] In addition, proper information about environmental issues can be provided by further combination: specified team or department for managing environmental issues, establishment of long term environmental objects, and publication of environmental report. Such information helps to reduce environmental pollutions in an efficient way.

<Figure 1> Proposed sub-dimensions of ELPs



Note: Environmental logistics practices (ELPs), Internal environmental management (IEM), Environmental sourcing and packaging (ESP), Environmental process design (EPD)

For example, Yongma Logis, which is one of the premier third-party logistics (3PL) companies in South Korea, has developed their own audit system to reduce CO_2 emission. They may provide a differentiated service to the owner of goods through the development of this system, thus achieving their environmental performance.

Our second proposed dimension is ESP. Environmental purchasing

18) e.g. Holt and Ghobadian(2009).
19) e.g. González-Benito and González-Benito(2006) ; Lin and Ho(2011).
20) Fernández et al.(2003), p.641.

refers to the purchasing activities, which include the pollution reduction, reuse and recycling of the materials.[21] In order to enhance these activities, environmentally authorized suppliers are important due to the fact that these activities may depend on the selection of those suppliers. It has been known that environmental purchasing can also contribute to the development of environmental packaging practices. Better packaging may reduce material usage, while at the same time increasing space utilization.[22]

<Table 1> Measurement items for environmental logistics practices (ELPs)

Items Your organizations:	Mean	S.D.
Internal environmental management (IEM)	2.47	1.14
1. Building green partnership with other players	2.74	0.97
2. Adopting standardized greenhouse gas (GHG) audit system	2.35	1.08
3. Building specific team or department for environmental issues	2.64	1.22
4. Establishing long term environmental objectives	2.64	1.10
5. Publishing periodic environmental report	2.22	1.18
Environmental sourcing and packaging (ESP)	3.04	1.00
6. Purchasing environmentally friendly products and materials	3.09	1.00
7. Adopting environmental criteria in supplier selection	2.91	0.98
8. Utilizing recyclable and reusable outer packaging in logistics process	3.14	1.03
9. Utilizing ecological materials for inner packaging	3.01	0.98
Environmental process design (EPD)	2.87	1.03
10. Pursuing logistics process rationalization by using LIS and IT	3.67	0.96
11. Designing reverse logistics process for reuse, recycle and returnable	2.97	1.06
12. Building or designing sustainable warehouse	2.65	1.07
13. Pursuing modal shift – transferring freight to greener modes	2.59	1.02
14. Changing facility location for environmentally oriented logistics network	2.34	1.00
15. Adopting unit load system (ULS) through logistics standardization	3.00	1.05

21) Carter et al.(1998), p.28.
22) Wu and Dunn(1995), pp.28-29.

The third dimension we propose is EPD. Traditional logistics system, which only focuses on logistics efficiency, creates an enormous amount of wasted energy. Process optimization, however, can save these energy assumptions while increasing its efficiency that may lead to positive impact on environmental performance. Moreover, it has been shown that those changes of logistics structure reduce the environmental impact.[23)] In particular, literatures have illustrated that modal shift, reverse logistics, designing sustainable warehouse, and facility location towards sustainability are known as most influential logistics activities for mitigating environmental impacts.

2. Scale development

We first developed a list of 21 measurement items of ELPs based on the environmental-related logistics literature[24)] and an interview with practitioners in the Korean logistics industry. Preliminary version of the questionnaire was then reviewed by academic and industrial experts to clarify the wordings in the measurement items. In this process, some items were subsequently modified, newly developed and discarded. The final version of survey instrument for ELPs was then presented to elicit managerial perception with environmental practices in the Korean logistics industry. This procedure ensure content validity and face validity of the measurement items.

After going through the above procedure, the list of 15 measurement items of ELPs was developed: 5 items for IEM, 4 items for ESP, and 6 items for EPD (see Table 1). Each item was rated on a five-point Likert scale (1: not considering it at all, 2: planning to consider it, 3: considering it currently, 4: initiating implementation, 5: implementing successfully) according to the following question: “please assess the degree to which you have adopted or implemented the following environmental logistics activities in your company.”

3. Data collection

Our target respondents are Korean logistics firms (including logistics service

23) Arronson and Huge-Brodin(2006), p.411.
24) Wu and Dunn(1995) ; Fernández et al.(2003) ; Aronsson and Huge-Brodin(2006) ; González-Benito and González-Benito(2006).

provider, logistics subsidiaries or departments of manufacturer, and retailer and wholesaler) who possess at least one or more freighters and facilities. Those targeted respondents were identified from the list of member: Korea Integrated Logistics Association (KILA), Korea Transport Institute (KOTI), Korea Maritime Institute (KMI), Korea Productivity Center (KPC), and logistics MBA and Global Logistics Management Program (GLMP) in Inha University.

In the study, data collection was conducted through two-step approaches. In the first step, the final version of questionnaires was distributed to students enrolled in the logistics MBA program and GLMP in Inha University. As a result, out of a total of 151 survey questionnaires was emailed, 69 applicable questionnaires (sample 1) were returned. In the second step, we used a random e-mailing survey to logistics firms to secure a more representative sample. Of the 977 e-mailed surveys followed by telephone calls, 99 completed questionnaires (sample 2) were returned for the analysis.

To ensure data quality, we first performed a *t*-test to compare sample properties of the two samples: 69 samples from Inha members (i.e. sample 1) and 99 from others (i.e. sample 2). The result indicates that there were no statistical differences between two groups in all 15 measurement items at a five percent level of significance. It appears that it is reasonable to combine the samples from different groups into one applicable sample group for the data analysis.

We then divided 168 survey respondents into four groups (ranging from first to fourth quartile of respondents) to test a potential non-respondent bias of data. As a result, there were no statistically significant differences in the mean value of the 15 items between early (first quartile of respondents) and later (last quartile of respondents) groups indicating that the non-response bias was not a major problem in this study.[25)] Given the test results, multiple responses from the same companies were aggregated into one organizational response; the total sample case of this study was reduced to 129.

Our survey respondents were mainly from logistics managers who work at the different types of business: logistics service provider (89, 69.0%),

25) Armstrong and Overton(1977).

logistics subsidiaries or departments of manufacturer (27, 20.9%) and retailer and wholesaler (13, 10.1%). In addition, average work experience of respondents was roughly 12 years indicating that the respondents were said to possess managerial experience at the middle and upper management levels. In terms of organizational size, 30 percent was less than 100 employees while 18 percent was larger than 3,000 employees. The range from 101 to 500 accounted for about 30 percent, from 501 to 1,000 illustrated nearly 8 percent, and from 1001 to 3,000 demonstrated approximately 15 percent.

IV. Results

1. Preliminary evaluation for the ELPs instrument

On the basis of the relevant environmental logistics literature and the previous exploratory research[26], we conceptualized ELPs as three distinct dimensions including internal environmental management (IEM), environmental sourcing and packaging (ESP), and environmental process design (EPD). Descriptive statistics for each ELPs dimension are presented in Table 1. In particular, it seems that the level of consideration of IEM2 (mean 2.35), IEM5 (2.22), EPD13 (2.59), and EPD 14 (2.34) is relatively lower than other practices. This means that Korean logistics companies are reluctant to adopt these practices because of the concerns about investment and its recovery.

Preliminary evaluation of the ELPs instrument was accomplished by an examination of item-to-total correlation analysis in each sub-dimension (i.e. IEM, ESP, and EPD). In this analysis, measurement items that have low item-to-total correlation coefficients (lower than 0.5) were deleted to ensure data quality. Based on this preliminary examination, two measurement items (items No. 1 and No. 10) were deleted.

Guided by results from the preliminary test, confirmatory factor analysis (CAF) was performed to further eliminate items that disturb unidimensionality in each construct. It has been known that CFA is used to test how well measured variables represent a smaller number of unobserved or latent variables. Furthermore, CFA provides a more rigorous interpretation

26) Kim(2011).

of dimensionality than exploratory factor analysis (EFA). Based on the CFA results, 2 additional items were deleted (items No. 11, No. 12) for the data analysis, leaving 11 items (4 items for IEM, 4 items for ESP, and 3 items for EPD) as shown in Table 3.

2. Validity and reliability of the ELPs scale

Construct reliability is similar to Cronbach's alpha, and both values reflect internal consistency of each indicator. Table 2 shows construct reliabilities that were examined from CFA analyses, which were conducted separately for each sub-dimension. In the table, Cronbach's alpha was also analyzed for evaluating EPD dimension because of the fact that construct reliability from CFA would not be meaningful if the construct has fewer than four items. The test results show that construct reliability scores of three factors are all greater than 0.70 that are commonly recommended as a benchmark.

Convergent validity refers to the extent to which items of a construct share a high proportion of variance in common. Table 3 demonstrates a series of goodness-of-fit indices for each dimension. Although the χ^2 statistics for IEM and ESP are significant ($\chi^2 = 12.15$, $df = 2$, $p < 0.001$), other fit indices indicate an reasonably acceptable fit (i.e. GFI > 0.90, NFI > 0.90, CFI > 0.90, RMR <0.05).

<Table 2> Construct reliability of ELPs scale

Factors	No. of items	Construct reliability	Ranges of item to total correlations
Internal environmental management (IEM)	4	0.90	0.76-0.85
Environmental sourcing and packaging (ESP)	4	0.91	0.79-0.81
Environmental process design (EPD)	3	0.80[a]	0.54-0.74

Note: a Cronbach's alpha

In terms of EPD, as a saturated model, it appears that χ^2 statistics is insignificant, which means that the model fully fits the data (H_o: $\sum = \sum(\theta)$). In addition, each indicator of the all three constructs has a standardized loading with highly significant *t*-statistics, suggesting that all indicators provide good measures to their latent constructs. Given the test results, convergent validity is said to be adequately achieved.[27)]

27) Anderson and Gerbing(1998), p.416.

<Table 3> Results of confirmatory factor analysis (CFA) for IEM, ESP, and EPD

Construct and indicators		Standardized loading	t-statistics	Goodness-of-fit indices
IEM	IEM2	0.80	10.70	χ^2 = 12.15 (0.00), *df* = 2,
	IEM3	0.88	12.36	GFI = 0.95, NFI = 0.97,
	IEM4	0.89	12.60	CFI = 0.97, RMR= 0.03
	IEM5	0.88	12.31	
ESP	ESP6	0.87	12.09	χ^2 = 14.46 (0.00), *df* = 2,
	ESP7	0.84	11.48	GFI = 0.95, NFI = 0.97,
	ESP8	0.83	11.15	CFI = 0.97, RMR = 0.03
	ESP9	0.85	11.51	
EPD	EPD13	0.71	8.00	χ^2 = 0.00 (1.00), *df* = 0,
	EPD14	1.00	11.44	GFI = 1.00, NFI = 1.00,
	EPD15	0.58	6.56	CFI = 1.00, RMR = 0.00

Discriminant validity refers to the extent to which a construct is distinct from other constructs, and it can be assessed by performing a chi-square difference test on the values that were obtained from the constrained (i.e. the correlation between two constructs is fixed as equal to one) and unconstrained models. It has been argued that if the fit of the unconstrained model is significantly better than that of the constrained model, then discriminant validity is achieved.[28)] As a result, there were the statistically significant results ($p < 0.001$) of the chi-square difference test that attest to the presence of discriminant validity between all possible pairs of the factors (i.e. $\Delta\chi^2$ for IEM-ESP is 13.06, IEM-EPD is 14.87, ESP-EPD is 19.57).

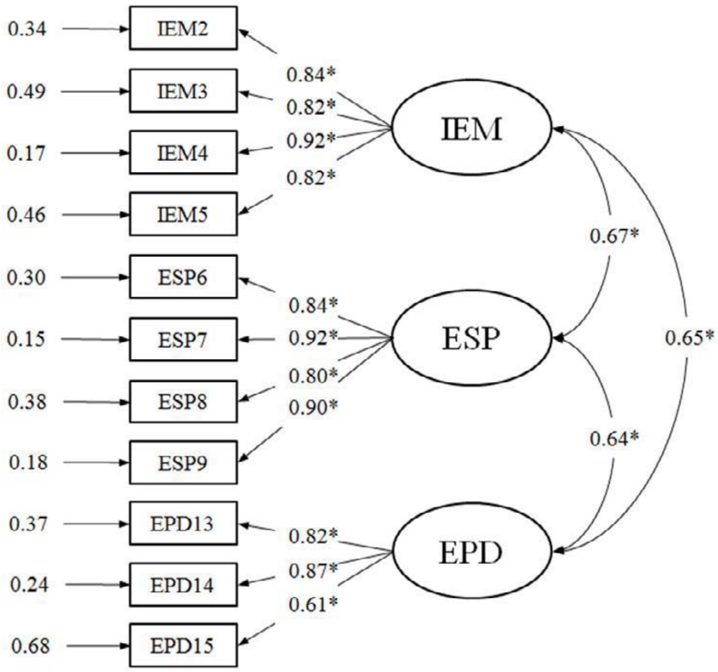
3. Test of first-order and second-order models

In this section, we attempt to test the ELPs measurement model in two stages: a test of the three basic dimensions (i.e. first-order model) and a test of the higher-order factor (i.e. second-order model). In the first-order model, IEM, ESP, and EPD are correlated, but not governed by a higher-order factor, i.e. ELPs (see Figure 2). In the second-order model, on the other hand, IEM, ESP, and EPD are governed by a higher order factor (see Figure 3). The results of model estimation for first-order and second-order models are

28) Anderson and Gerbing(1998), p.416.

presented in Figures 2-3 and detailed as follows.

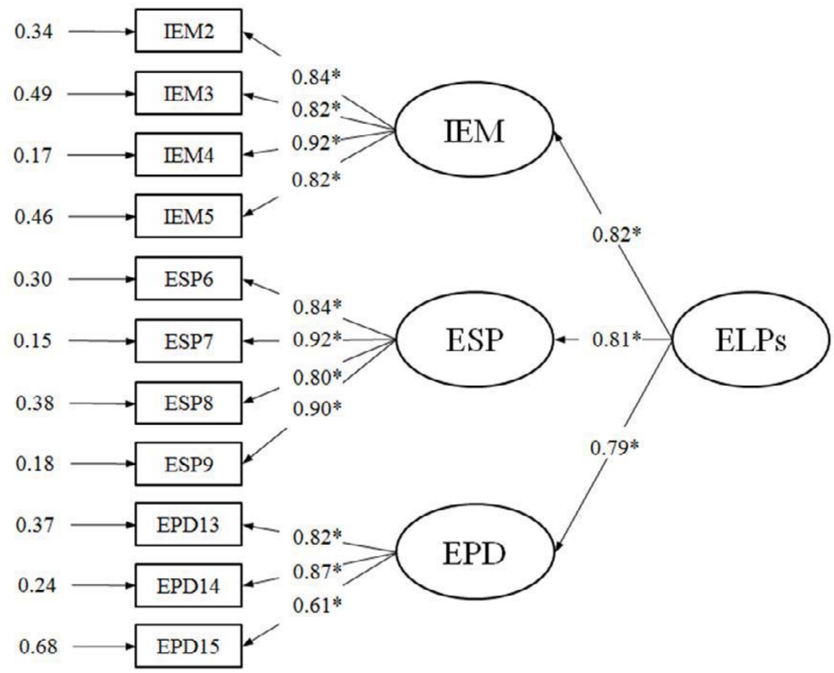
<Figure 2> First-order factor model of environmental logistics practices (ELPs)



Note: *indicates significance at p < 0.001 level

In the first step, we test whether the three sub-dimensions are well supported as descriptors of ELPs. As illustrated in Figure 2, the model entails the three first-order constructs, observed indicators of each construct, and measurement error terms. To evaluate the model fit, χ^2 to degrees of freedom statistics, goodness-of-fit index (GFI), normed fit index (NFI), comparative fit index (CFI) and root mean residual (RMR) were used to determine how well the data fit the proposed model. The overall fit indices show that the model fits the data well (χ^2 = 12.15 (0.00), *df* = 2, GFI = 0.95, NFI = 0.97, CFI = 0.97, RMR= 0.03). Moreover, the significant factor loadings and correlation coefficients that were obtained from a test of three basic dimensions are shown in Figure 2, which seems to lend support to that those dimensions are well suited for evaluating ELPs.

<Figure 3> Second-order factor model of environmental logistics practices (ELPs)



Note: *indicates significance at $p < 0.001$ level

In the next step, a second-order CFA is further employed to achieve strong validity and reliability,[29] as well as to determine whether ELPs may be viewed as a higher order factor. Using the same measurement indicators, we model ELPs as a second-order factor (see Figure 3). Various model fit indices are consistently acceptable at the commonly recommended benchmark (χ^2 = 12.15 (0.00), *df* = 2, GFI = 0.95, NFI = 0.97, CFI = 0.97, RMR= 0.03),[30] and the significant factor loadings also presented in Figure 3. On top of that, all the lambda coefficient estimates of IEM (0.82), ESP (0.81), and EPD (0.79) are significant. These results lead us to conclude that the second-order factor structure of ELPs can be adequately supported, thus providing evidence that the dominant dimensions of ELPs include IEM, ESP, and EPD.

29) Marsh and Hocevar(1985), pp.562-582.

30) These model fit indices are completely identical with the first-order factor model (Figure 2) because the degrees of freedom are same when the number of first-order constructs is three (Lai et al., 2002).

V. Discussion and implications

In the first-order model, internal environmental management (IEM), environmental sourcing and packaging (ESP), and environmental process design (EPD) are positively correlated with significant factor loadings and acceptable model fit indices. It means that three proposed basic dimensions appear to be well suited for measuring environmental logistics practices (ELPs). In the second-order model, it has also shown that the significantly positive relationship between three sub-dimensions (i.e. IEM, ESP, and EPD) and its higher construct (i.e. ELPs) along with excellent fit indices. Our proposed hierarchical structure for evaluating ELPs is therefore supported with systematic and scientific procedures, implying that ELPs can be conceptualized as a multi-dimensional measure comprising IEM, ESP, and EPD.

These findings make some academic, industrial contributions, and suggest several applications for the research as follows. Our research findings are original in that an attempt to identify measurement dimensions for evaluating ELPs. The results of this research generally support the conceptualization of ELPs making up of other latent factors (i.e. IEM, ESP, and EPD) at a higher-order level. Given the lack of a theory-based factor structure from the environmental logistics literature and the fact that ELPs have not been sufficiently conceptualized in the previous studies, our research findings would contribute to the environmental logistics literature by developing and validating a measurement scale.

In addition, the measures newly developed in this study may have implications for investigating and assessing the relationship between logistics practices towards sustainability and its performance. This means that ELPs measures can be used to assess and investigate not only the extent of environmental logistics activities but also the impact of its practices on business performance. For example, Zhu et al.have shown the positive relationship between the green supply chain management (GSCM) practices and performance in the Chinese automobile industry.[31] By utilizing GSCM

31) Zhu et al.(2007).

practices measures which were developed in the previous studies, they empirically investigated and assessed the relationship, and linked GSCM practices with its performances. In this regard, the ELPs scale developed in this study gives additional insights to logistics researchers for further investigating and assessing performance outcomes.

On the basis of the interviews with Korean logistics practitioners, the authors noticed that the logistics firms are now integrating their environmental concerns into their strategic and operational activities. In this context, this study is one of the initial efforts to give some guidance on how to better manage and pursue an environmental logistics strategy to logistics managers. That is to say, logistics managers can assess the level of their environmental practices by using the ELPs measurement. These measures for evaluating ELPs may allow logistics managers to better understand their current environmental strategy especially IEM, ESP, and EPD.

Policy implication is also manifested in our research findings. Korean government is now pushing ahead with its logistics related to environmental legislation (e.g. ‘The Act on the Development of Sustainable Traffic Logistics’). The basic purpose of this legislation is to maximize energy efficiency and resource recycling, and to minimize wastes in each function of logistics. In order for these purposes to be put into practice, there must be an understanding from government of its current state of environmental logistics activities. In this regard, ELPs measures adequately developed in this study may help policy makers to understand the current state of ELPs. Furthermore, these measures would help support the governmental decision making especially regarding “green logistics certification system”.

VI. Conclusion

There were a few efforts to measure environmental logistics practices (ELPs) in the previous studies; however, no one reflects the multi-dimensional nature of ELPs in empirical approach. Therefore, the present study has attempted to develop and validate a reliable scale for evaluating the different facets of ELPs. Based on the relevant literature and the previous exploratory research,[32)] ELPs was proposed as a three *a priori* dimensions: internal environmental management (IEM), environmental sourcing and packaging (ESP), and environmental process design (EPD). The results show that validity and reliability of the scale for measuring ELPs are adequately established.

Although this study has provided relevant insights into the better understating of ELPs, there is a limitation which should be avoided in further research. First, we only measure the adoption of ELPs rather than the resulting performance outcomes. During the literature review, as we mentioned earlier, we found that the significantly positive relationship between environmental logistics activities and its performance.[33)] Therefore, further research would be directed towards investigating those relationships. Last, the sample size in this study, while adequate for the purpose at hand, was relatively small (129 individual logistics firms in this study). A lot more data should be collected in further study to rigorously generalize the research findings. *

32) Kim(2011).

33) e.g. González-Benito and González-Benito(2005).

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